DISTRIBUTION AND CURRENT STATUS OF RODENTS IN THE GALÁPAGOS

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INTRODUCTION

The uniqueness and scientific importance of the Galápagos Islands has long been recognized, although the creation of the National Park in 1959 came after several centuries of sporadic use and colonization by man. Undoubtedly, the lack of water in the islands has been their savior by limiting the extent and duration of many early attempts to colonize. Even so the impact of man has been severe in the Archipelago, and the biggest problems for conservation today are the introduced species of plants and animals. These introduced species are frequently pests to the human inhabitants as well as to the native flora and fauna, to the former by damaging crops and goods, and to the latter by competition, predation and transmission of disease.

The feral mammals in particular constitute a major problem, principally due to their size and numbers. The destructive capacity of goats, pigs, dogs and cats has been proved enormous in the islands. The introduced commensal rodents have contributed to the loss and endangered status of one race of giant tortoise (MacFarland 1974), and of the dark-rumped petrel (Cruz & Cruz 1987). The native rats have also suffered from the introduced species, but mostly before the risk was realized, as seven species had been reduced to three before the Park was even created. Modern methods of pest control bring the possibility of eradication nearer, but it is important to know the extent and relative abundance of the existing populations, both native and introduced. This article summarizes the knowledge of the present status of the rodent species in the Galápagos Archipelago as an aid to the Galápagos National Park Service (GPNS) and the Charles Darwin Research Station (CDRS) in their continuing efforts to protect the unique wildlife of the islands.

ENDEMIC RODENTS

Seven species of endemic rice rats are known from the Archipelago, of which the seventh was only relatively recently discovered from owl pellets on Fernandina island (Hutterer & Hirsch 1979). Brosset (1963) and Niethammer (1964) have summarized the available information on the six species known at that time, including last sightings and probable dates of extinction. Galápagos rice rats belong to two closely related genera of *oryzomys* rodents and were distributed among the six islands (Table 1).

Patton and Hafner (1983) concluded that rats of the genus *Nesoryzomys* arrived in the Archipelago first, and that the four larger species (excluding *N. fernandinae* which was not considered in their study) may be considered races of a single species differing only in pelage color. *Oryzomys* rats arrived much later and the two known species may also be conspecific, and closely related to *O. xantheolus*, an extant species of coastal Peru. Of the four extinct species, nothing is known of their biology and ecology and the arrival of the commensal ship rat, *Rattus rattus*, has been implicated in their subsequent extinction (Brosset 1963).

The extant species are only slightly better known and work has been done on *O. bauri* (Clark 1978; 1980) and to a much lesser extent *N. narboroughi* (Eshelman 1978). The present status of *O. bauri* is apparently thriving on Santa Fe, with high population levels at least along the coast. Brosset estimated

Table 1. Distribution of rats in the Galápagos Archipelago.

GENUS	SPECIES	ISLAND
Oryzomys		
	O. galapagoensis	San Cristóbal (extinct)
	O. bauri	Santa Fe
Nesoryzomys		
	N. indefessus	Santa Cruz and Baltra (extinct)
	N. darwini	Santa Cruz (extinct)
	N. narboroughi	Fernandina
	N. fernandinae	Fernandina
	N. swarthi	Santiago (extinct)

the total population in 1963 at 1000 - 2000 animals, distributed primarily in the littoral zone, and very sparsely in the central plain. Clark (1978) estimated numbers between 10,000 and 100,000 individuals in varying densities over the island, and he also noted stability of *O. bauri* populations over the study period. On Fernandina the population levels of the two species are not known. There is some evidence that the smaller *N. fernandinae* occurs inland on the lava beds, at least in the vicinity of Cape Hammond, while *N. narboroughi* is common along the coast (Adsersen 1987). Certainly there is abundant evidence of small rodents in the mangroves around Punta Espinosa in the form of nibbled fruits of white and black mangrove (Key and Muñoz 1992, pers. obs.). There remains the slight chance that small populations of *Nesoryzomys* species still exist in the highlands of Santa Cruz, and possibly even in Santiago (Peterson 1966); in 1980 Steadman found the remains of a small species of *Nesoryzomys* on Isabela (Steadman & Ray 1982) but no more is known of this discovery.

The giant rat, *Megaoryzomys curioi*, represents a third endemic rodent group which arrived independently and probably early on (Steadman & Ray 1982). This species is known only from subfossil remains on Santa Cruz and Isabela and appears to have become extinct within the last few centuries, possibly due to the introduction of feral mammals. Giant rats have never been seen alive and nothing is known of their biology.

INTRODUCED RODENTS

The three pan-global commensal rodents, *Rattus rattus*, *R. norvegicus* and *Mus musculus* are now all in the Archipelago. *Rattus rattus* was probably the first species of rat to arrive on whaling boats and pirate ships in the late 1600's to James Bay on Santiago and then spread to Bartolomé. A second introduction occurred during the 1800's on Floreana, and then to San Cristóbal and Isabela by the spread of the human colonies. The third and most recent introduction occurred on Santa Cruz and Baltra islands around the time of World War II (Patton et al. 1975). Pinzon was used by whaling ships extensively in the 1800's and was either a fourth point of introduction, or was infested with rats from the Floreana-San Cristóbal-Isabela group (Patton et al. 1975). The exact dates of arrival for most of the islands are not known, but ship rats were present on Santiago when Darwin arrived in 1835, were first found on Pinzon in the 1890s, on Santa Cruz after 1934, and on Seymour

Norte, Islote Pitt and Isla Mosquera in 1983 (Anon. 1985; Calvopia 1984; Clark 1978). There are three races present in the Archipelago, the so-called subspecies *rattus*, *alexandrinus* and *frugivorous*, but coat color is actually considerably more varied and Patton et al. (1975) recognized seven color phenotypes. The ship rat is now on 10 islands and is a major pest, not only in settlements and farms but also in the National Park where it attacks tortoise eggs and emergent young, and the eggs and chicks of ground nesting sea birds, such as the dark-rumped petrel (e.g., Harris 1967; Kramer 1974; Snow 1964). A lot of effort has been expended by the GNPS and the CDRS towards eradication on some infested islands, with success on Islote Pitt (Muñoz 1993), but failure on the larger Pinzon. The policy is now for seasonal rat control on Floreana and Santa Cruz around the dark-rumped petrel colonies during the nesting season. Populations of the ship rat in the Archipelago are apparently thriving; Clark (1978) considered that Santa Cruz has some of the highest densities of rats in the world, increasing the risk of further spread by tourist and fishing boats, especially during El Niño years when population densities peak and rats are frequently seen swimming off shore.

Mus musculus was probably not far behind *R. rattus* in arrival to the Archipelago, because they are typically brought in produce to inhabited islands, including Santiago (now no longer inhabited), Floreana, San Cristóbal, Isabela and Santa Cruz (Muñoz, pers. obs.). On Santa Cruz mice were first seen in the 1940's, and quickly became abundant (Kastdalen 1982). In 1982-3 they arrived on Plazas Norte and Sur (Calvopia 1986) and in 1989 they were also found on Seymour Norte and Islote Mosquera. They are now found on seven islands and are a major nuisance in houses, especially during rainy years when they are very abundant. Mice also occur in the National Park, but nothing is known of the ecology of feral populations and they are not implicated as major pests as is *R. rattus*. They may contribute to cactus mortality on Plazas since their introduction during the 1982-83 El Niño event (Snell et al. 1993). Present status is thriving, with some risk of further introductions to other islands via boats.

Rattus norvegicus is the largest of the three commensal species and the most aggressive. It was first identified on Santa Cruz in 1984, and probably arrived one to two years earlier from an unknown source (Fiedler 1984). It is also reported to occur on San Cristóbal (Sivinta 1988). A study done in 1988 on Santa Cruz found that their distribution had expanded from Puerto Ayora to Bellavista, but that brown rats were confined to the houses and were not found along the road between the villages (Sivinta 1988). The ship rat was still the dominant species, even in houses. A second study in 1993 sampled the road from Puerto Ayora to the canal of Itabaca, and several sites in the agricultural zone; *R. norvegicus* had increased its range up the south side of the island to the *Scalesia* zone (Los Gemelos) and just above the *Miconia* zone at Media Luna (Key et al., in preparation). The brown rat had not displaced *R. rattus* but had become the dominant species in Puerto Ayora and Bellavista and could be found in the National Park as well as in the villages. It is not clear whether in the future *R. norvegicus* will displace *R. rattus* or whether the two species will continue to co-exist.

DISCUSSION

The relatively recent arrival of *R. norvegicus* is important, indicating that new species are still arriving in the Archipelago, and that the GNPS needs to give serious consideration to the creation of a quarantine center and adherence to rigid regulations. If enough individuals of an animal this size can arrive to become established, how many other species of potentially harmful invertebrates and plants may also be colonizing the islands? It is alarming to note that Patton et al. (1975) found relatively high levels of heterozygosity in ship rats from Wreck Bay, Academy Bay and, especially, Baltra island from which they concluded that constant immigration was occurring. The implications for conservation, of the arrival of the brown rat are serious; as it is a larger, more aggressive species, young tortoises and petrel chicks will need to be protected for longer, with a concomitant increase in the costs of rat control and in the captive breeding programs. As this species is also a better digger than the ship rat, tortoise eggs in the nesting sites may also require protection.

The CDRS and the GNPS are very concerned with the threat of the accidental introduction of commen-

sal rodents on Santa Fe and Fernandina (the apparent cause of extinction of other endemic rice rats). The CDRS is considering starting captive breeding programs with all three species so as to be ready with an emergency response in the event of a commensal invasion (Trillmich 1986). The current lack of knowledge of the biology and ecology of the rice rats, especially on Fernandina, poses serious limitations to the intention.

More basic research needs to be done, on both introduced and native rodents. Regular and systematic monitoring of the main islands is needed to check the distribution and relative abundance of the commensal species, and the status of endemics. The emergency recovery of the endemics should be considered now, and ecological studies should be initiated on the Fernandina rice rats. The ecology of house mice in the field is unknown, and in view of the hypothesis of Snell et al. (1993) should be investigated; in addition to their potential status as pests these small rodents may be filling the ecological niche left by the extinction of the native rats and their loss may have unforeseen ecological effect.

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POLLINATION OF *SCALESIA BAURII* SSP. *HOPKINSII* (ASTERACEAE) ON PINTA ISLAND

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Previous studies in the genus *Scalesia* have shown that *S. affinis* Hooker f., *S. helleri* Robinson, *S. pedunculata* Hooker f., and *S. aspera* Andersson can reproduce by autogamy (automatic self-pollination) (Rick 1966; McMullen 1987, 1990). In addition, the first three of these, as well as an unidentified species thought to be *S. retroflexa* Hemsley, are known to be pollinated by the endemic carpenter bee *Xylocopa darwini* Cockerell (Hymenoptera: Apidae) (Linsley et al. 1966; Rick 1966; Eliasson 1974; McMullen 1985). The flowers of *S. pedunculata* on Santa Cruz Island are also visited by the Galápagos fritillary butterfly *Agraulis vanillae galapagensis* Holland (Lepidoptera: Nymphalidae) (personal observation).

Pollination studies on an additional member of this genus, *Scalesia baurii* Robinson & Greenman ssp. *hopkinsii* (Robinson) Eliasson, were conducted on Pinta Island from 28 June - 20 July 1990 (Fig. 1). Pinta is one of the northern islands in the archipelago that the carpenter bee does not inhabit. Fifteen individuals, located between 15-67 m altitude on Pinta's southern slope, were selected for this study. One hundred inflorescences were bagged before their flowers had opened to determine if the plants could reproduce autogamously. One hundred open-pollinated inflorescences were marked as well, and then covered after being exposed for one week. All pollination bags were collected on the last day of the study and fruit counts were made. Flower observations were conducted to discover what insects made visits